

RHIC Status and Plans

Brief summary of RHIC RUN2001/2

Plans and goals for RUN2003

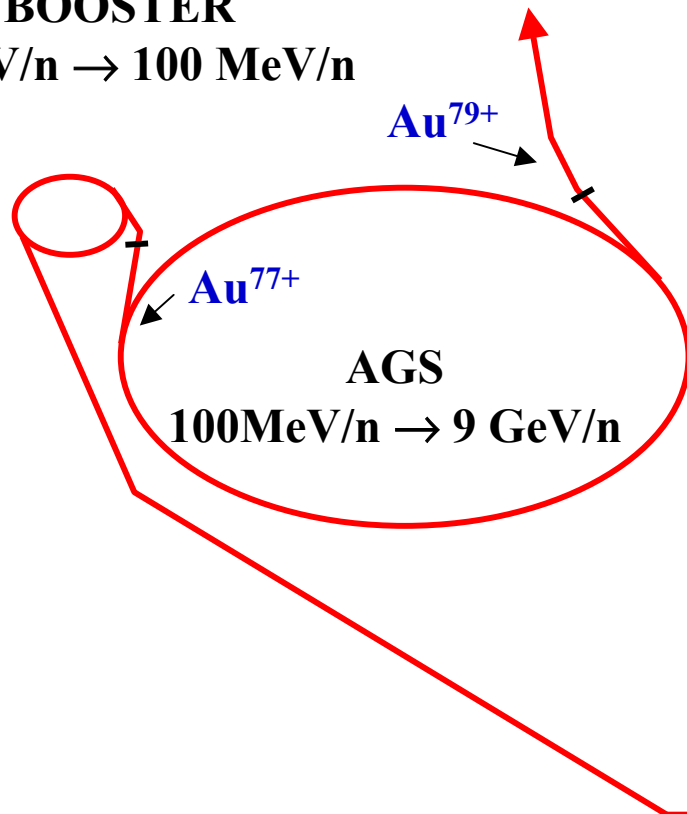
FY2001 - 02 RHIC Gold Parameters

- **55 - 56 bunches** per ring ✓ (110 bunches per ring tested, intensity limited)
- **7.5×10^8 Au/bunch @ storage energy** (intensity limited during acceleration)
- **1×10^9 Au/bunch achieved @ injection** ✓
- **Longitudinal emittance:** 0.5 eVs/nucleon/bunch (0.3-0.6 Design) ✓
- **Transverse emittance at storage:** $15 \pi \mu\text{m}$ (norm, 95%) ✓
- **Storage energy:** 100 GeV/ amu ($\gamma = 107.4$) ✓ 10 GeV / amu ($\gamma=10.5$) ✓
- **Lattice with β^* squeeze during acceleration ramp:**
 - $\beta^* = 3 \text{ m}$ and 10 m @ all IP at injection ✓
 - $\beta^* = 1 \text{ m}$ @ 8 and 2 m @ 2, 6 and 10 o'clock at storage ✓
- **Peak Luminosity:** $5 \times 10^{26} \text{ cm}^{-2} \text{ s}^{-1}$ ($2.5 \times$ design average) ✓
- **Bunch length:** 5ns (200 Mhz operational, diamond length: $\sigma = 20 \text{ cm}$) ✓

Au Injector Performance (needs update)

BOOSTER

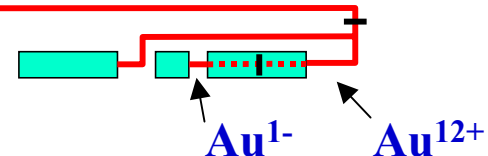
1 MeV/n \rightarrow 100 MeV/n



	<u>Intensity/RHIC bunch</u>	<u>Efficiency[%]</u>
Tandem	$5.4(3.8) \times 10^9$	
Booster Inj.	$2.9(2.2) \times 10^9$	54 (58)
Booster Extr.	$2.4(1.8) \times 10^9$	83 (81)
AGS Inj.	$1.2(0.9) \times 10^9$	50 (50)
AGS Extr.	$1.1(0.9) \times 10^9$	<u>92 (95)</u>
Total		<u>20 (23)</u>

Au³²⁺ : 1.4(1.1) part. μ A, 530 μ s (40 Booster turns)

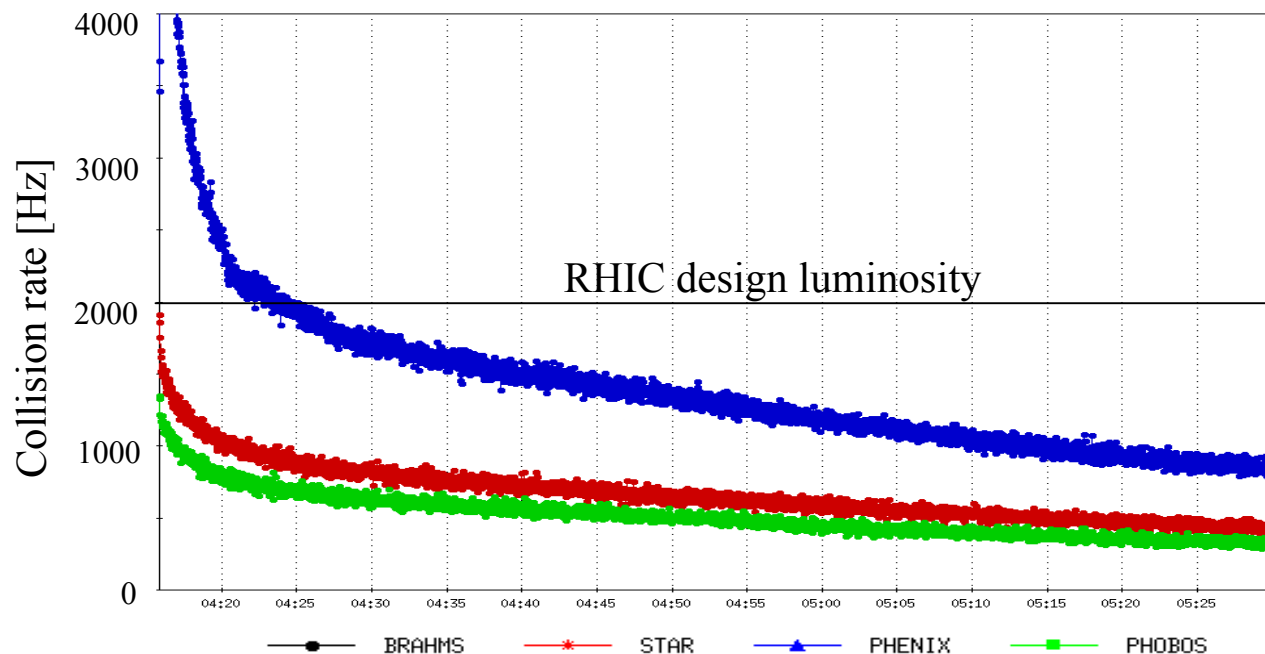
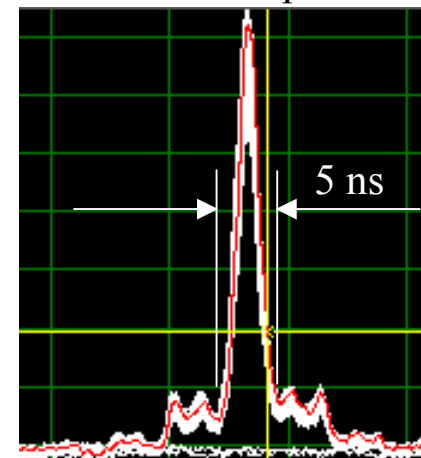
TANDEMS



RHIC performance

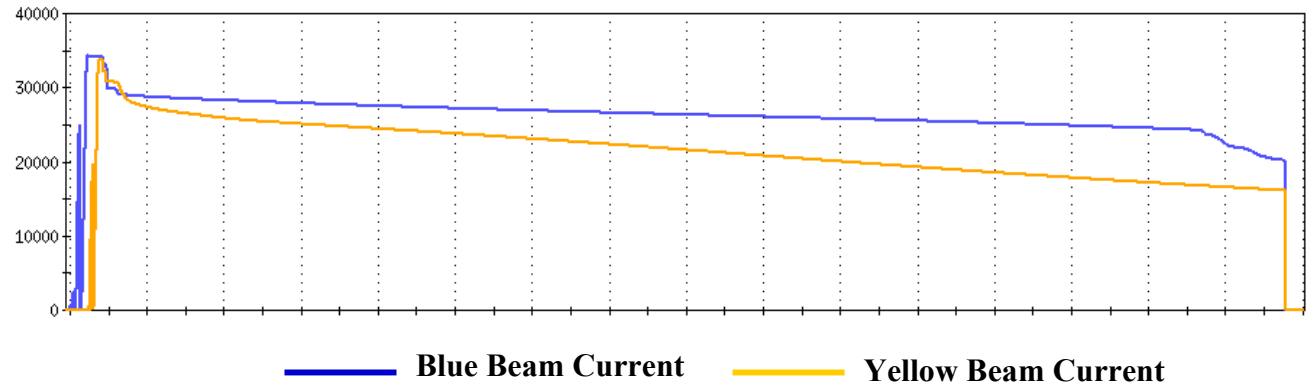
- Collisions at RHIC design beam energy (100 GeV/nuc)
- 200 MHz rf system operational
 - 5 ns bunch length and an interaction region with $\sigma \sim 25$ cm
- Luminosity exceeding RHIC design luminosity of $2 \times 10^{26} \text{ cm}^{-2} \text{ s}^{-1}$
- 40% availability is limiting total integrated luminosity

RHIC bunch profile

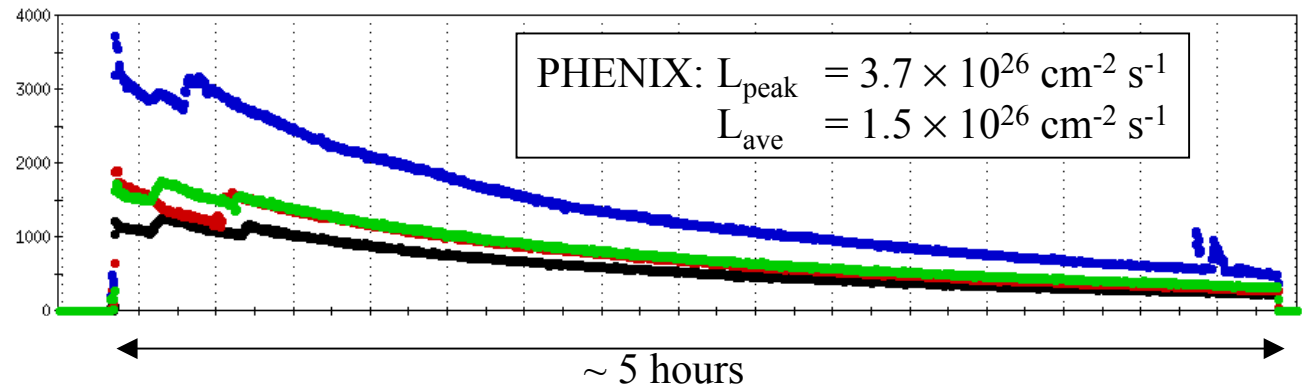


“Typical Store” # 1812

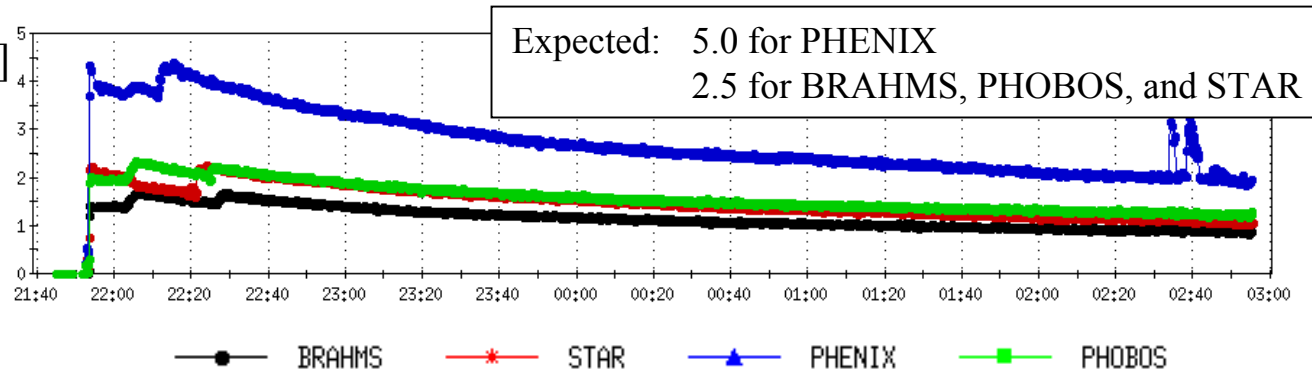
Beam currents [$\times 10^6$ ions]



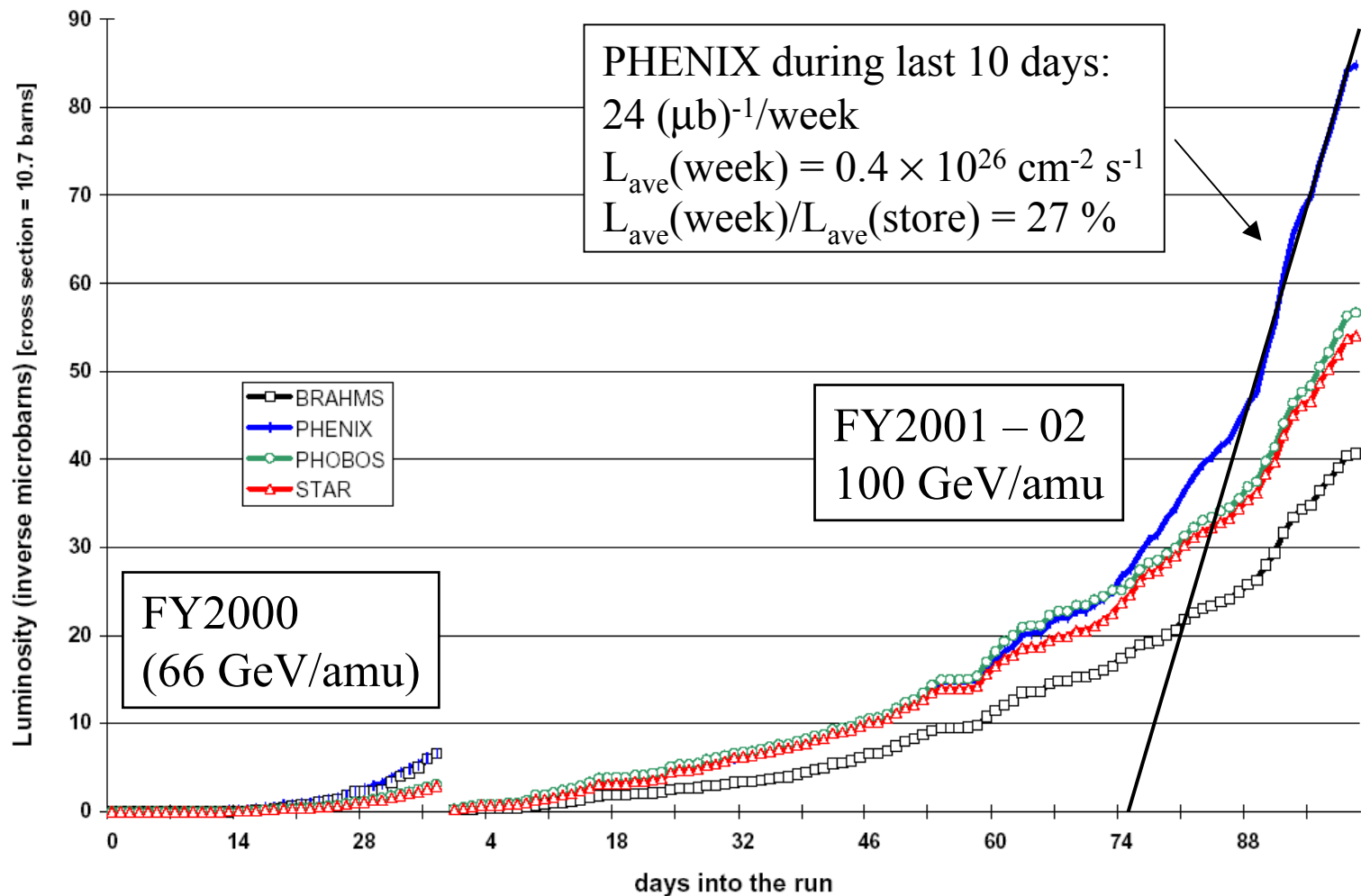
Collision rate [Hz]



Specific luminosity [$\text{Hz}/10^{18}$]

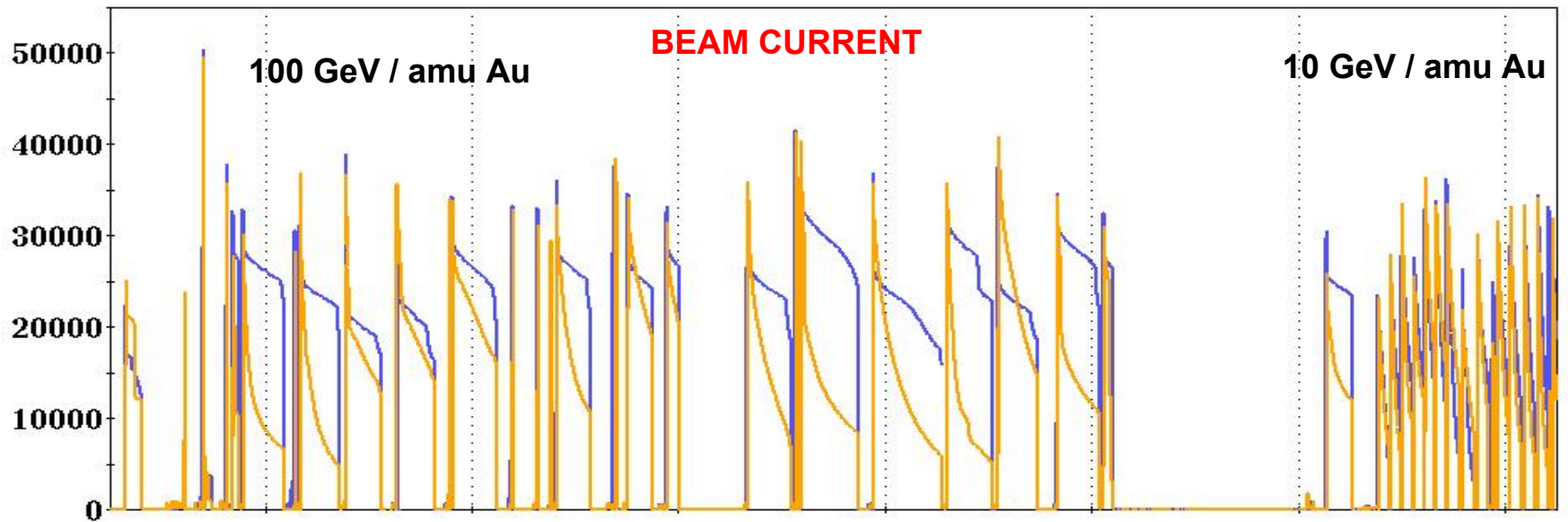


Integrated Au-Au luminosity



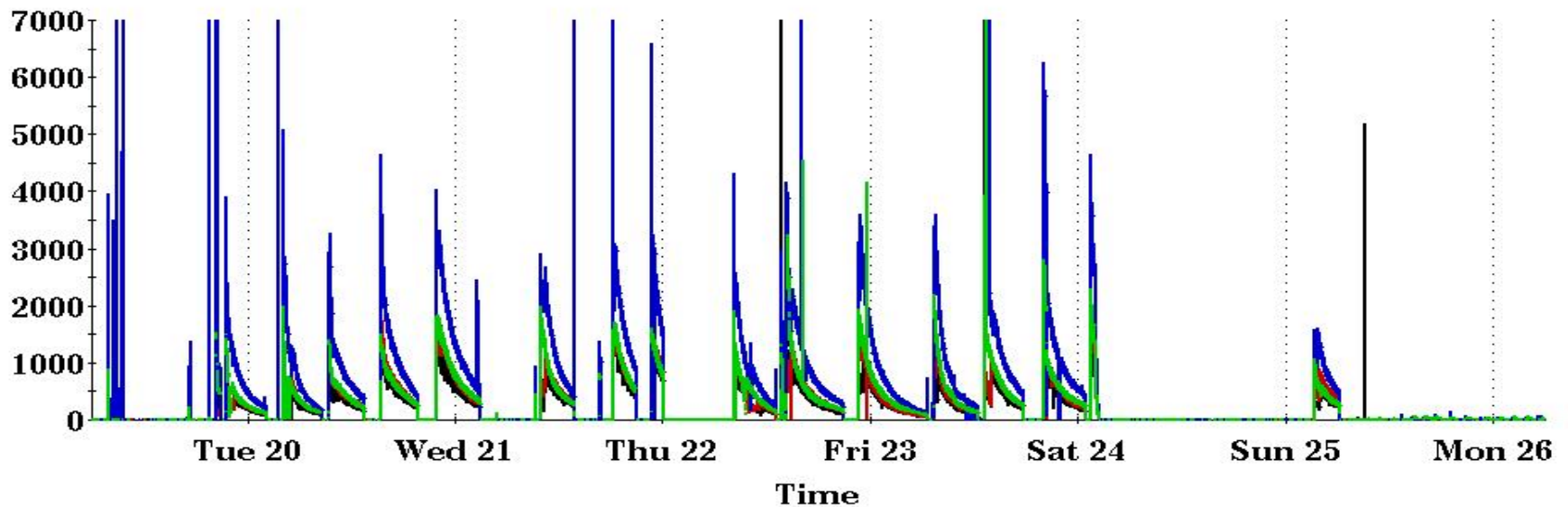
RHIC PERFORMANCE

$\times 10^6 \text{ Au}$



$\times 10^{23} \text{ cm}^{-2} \text{ sec}^{-1}$

LUMINOSITY



RHIC Au commissioning and challenges

- Single- and multi-bunch instabilities
 - Effect of vacuum chamber impedance, electron cloud (?)
- Intensity limitation for gold (?) due to vacuum break-down
 - Limited to about 40×10^9 Au/ring
 - Electron cloud ? Ion or electron desorption ?
- Intra-Beam Scattering (IBS)
 - Transverse and longitudinal emittance growth
 - Eventually will need electron cooling (see below)
- Beam-beam tune shift and spread
 - First strong-strong hadron collider (after ISR)

Transverse instabilities in RHIC

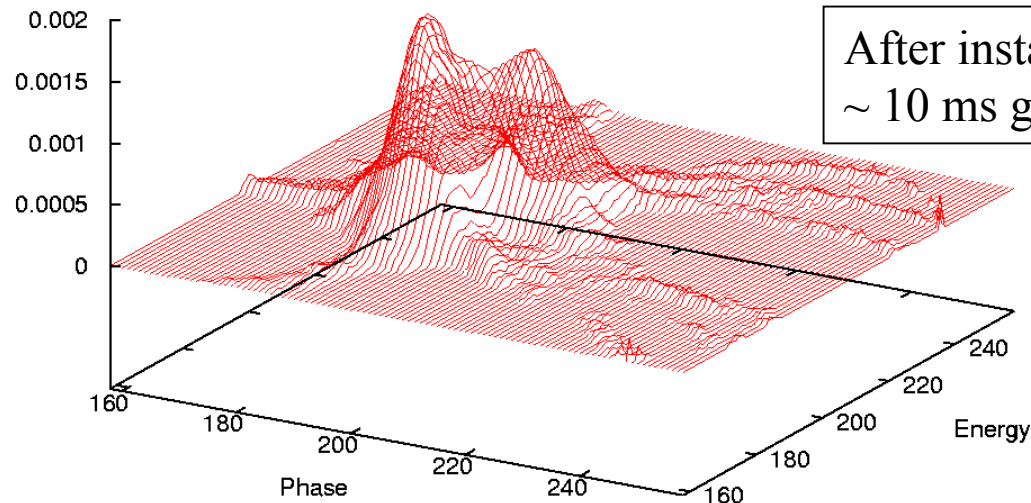
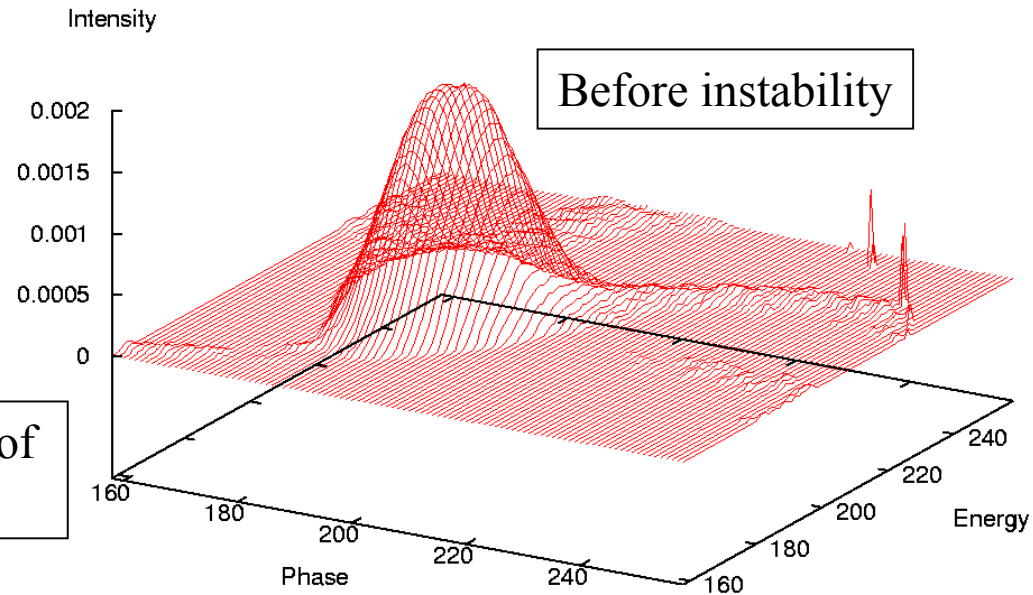
High sensitivity around transition

Effect of vacuum chamber impedance,
electron cloud (?)

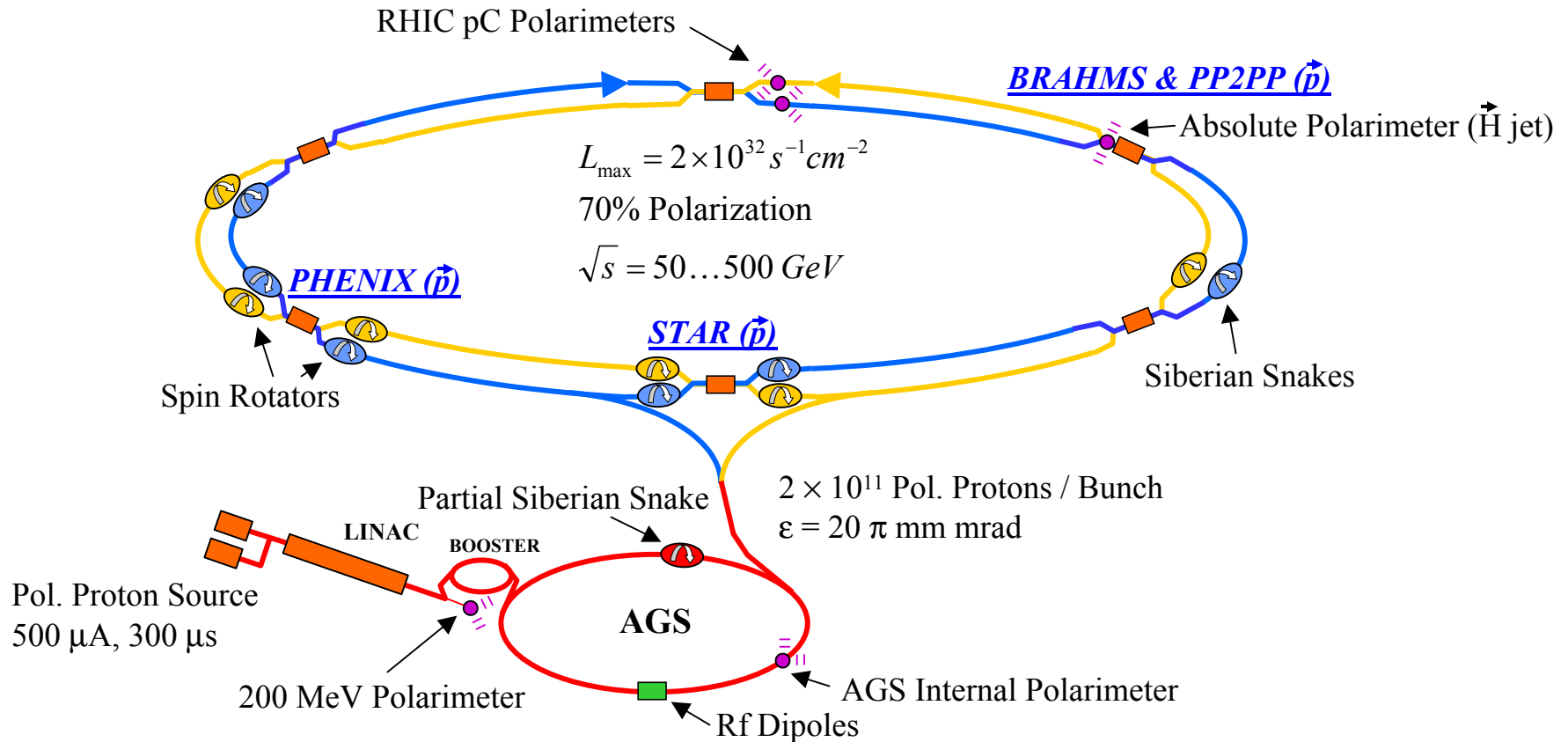
Cures: beam-beam tune spread,
octupoles, transverse dampers, rf
quad, ...

Tomographic reconstruction of
2D bunch density

Intensity



Polarized proton collisions in RHIC



High intensity polarized H^- source



KEK OPPIS
upgraded at TRIUMF

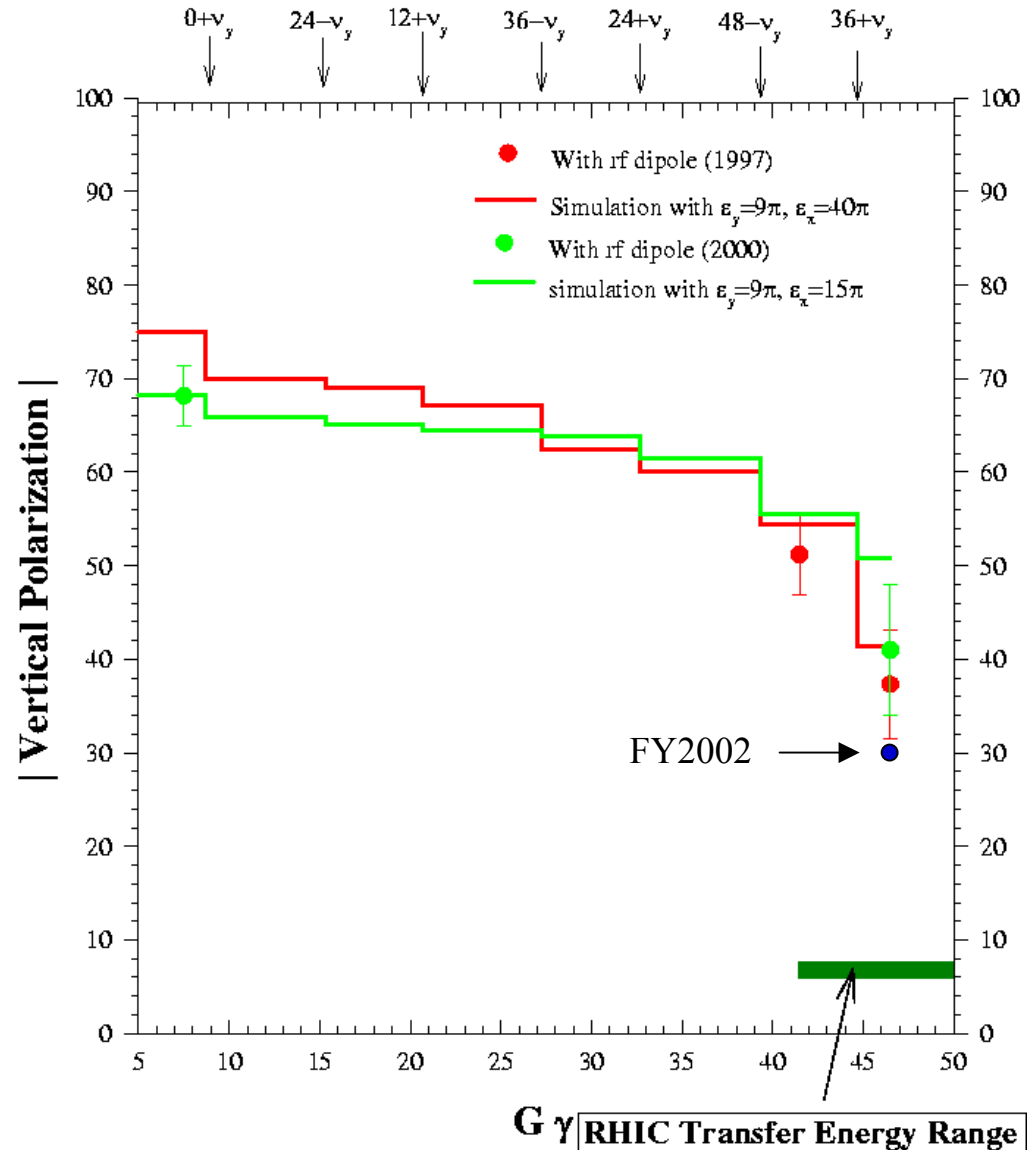
70 - 80 % Polarization

15×10^{11} protons/pulse
at source

6×10^{11} protons/pulse
at end of LINAC

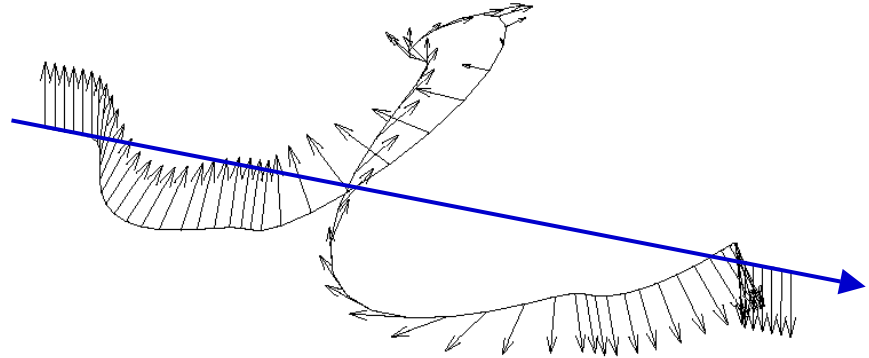
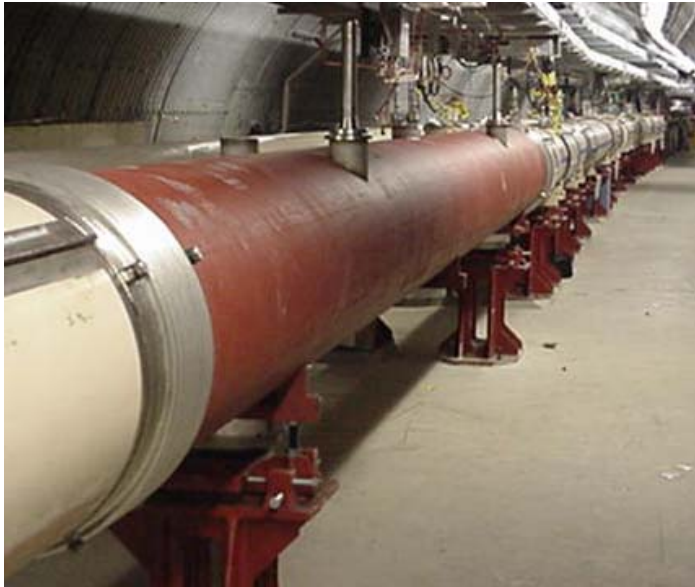
Proton polarization at the AGS

- Full spin flip at all imperfection resonances using partial Siberian snake
- Full spin flip at strong intrinsic resonances using rf dipole
- Remaining polarization loss from coupling and weak intrinsic resonances
- Larger polarization loss in FY2002 due to lower ramp-rate motor-generator and higher bunch intensity (?)

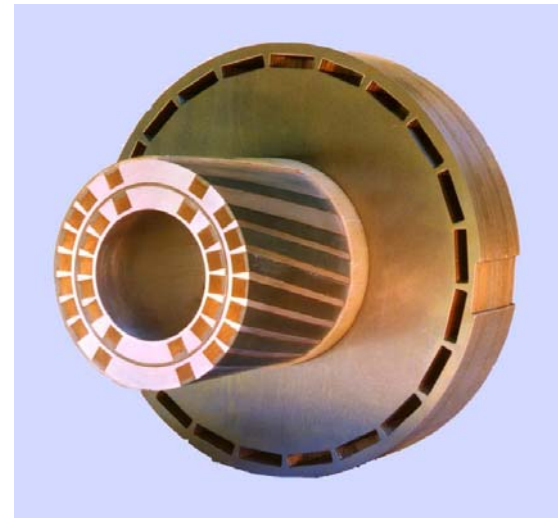


First Siberian Snake in RHIC Tunnel

Siberian Snake: 4 superconducting helical dipoles, 4 Tesla,
2.4 m long with full 360° twist

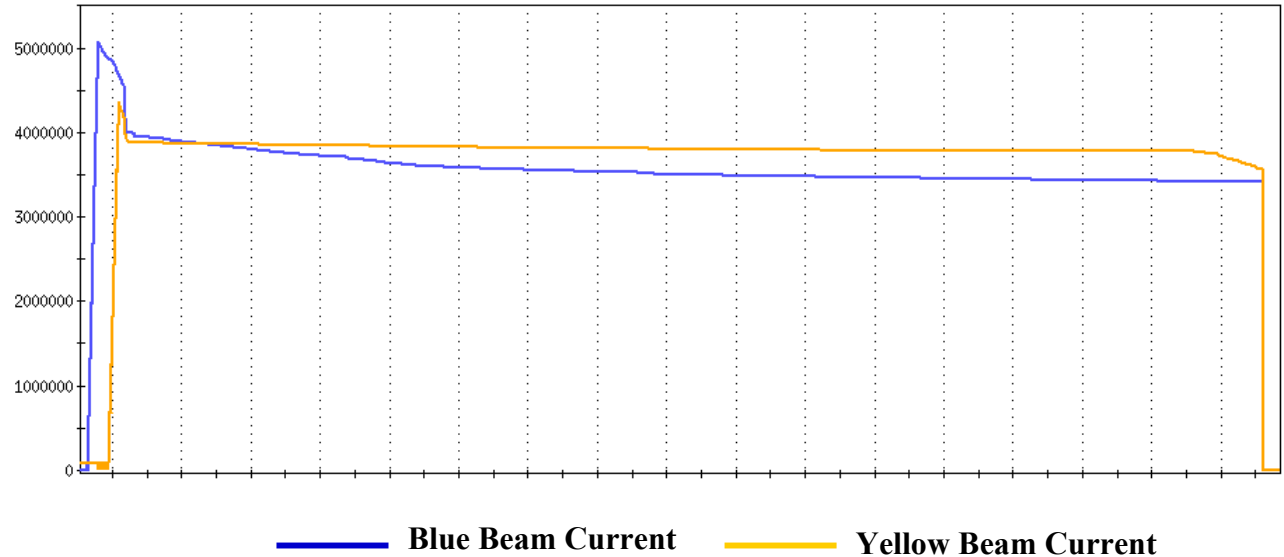


Funded by RIKEN, Japan
Designed and constructed at BNL



“Typical Store” # 2304

Beam currents [$\times 10^6$ ions]

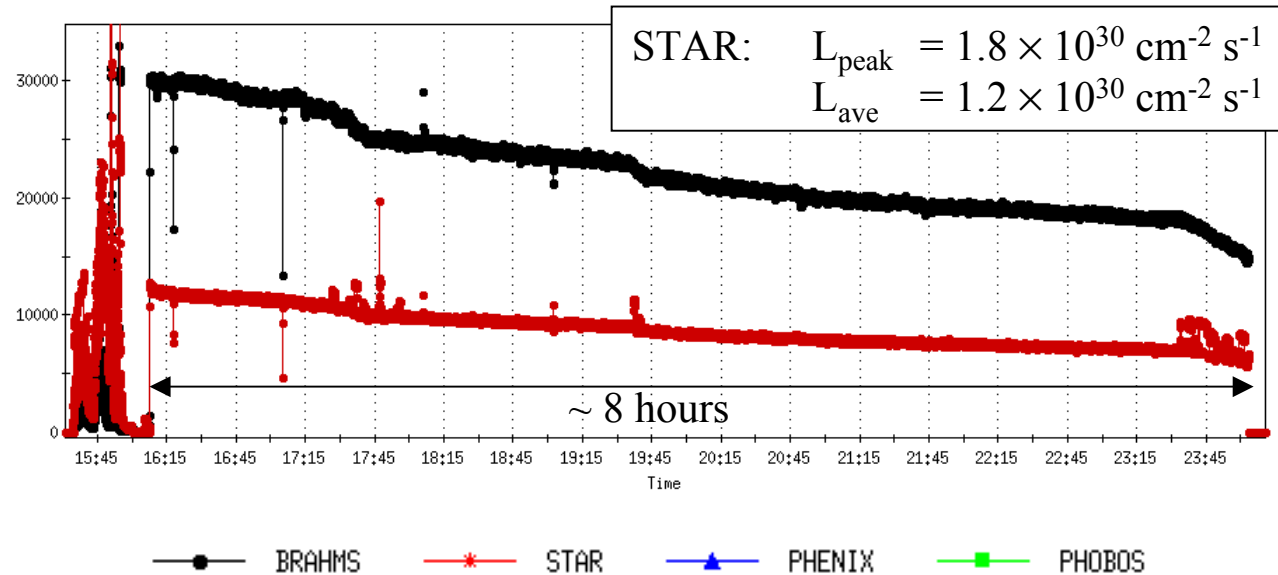


Collision rate [Hz]

Vernier scans:

STAR: $10^4 \rightarrow 0.6 \times 10^{30} \text{ cm}^{-2} \text{ s}^{-1}$

PHENIX: $10^4 \rightarrow 1.6 \times 10^{30} \text{ cm}^{-2} \text{ s}^{-1}$



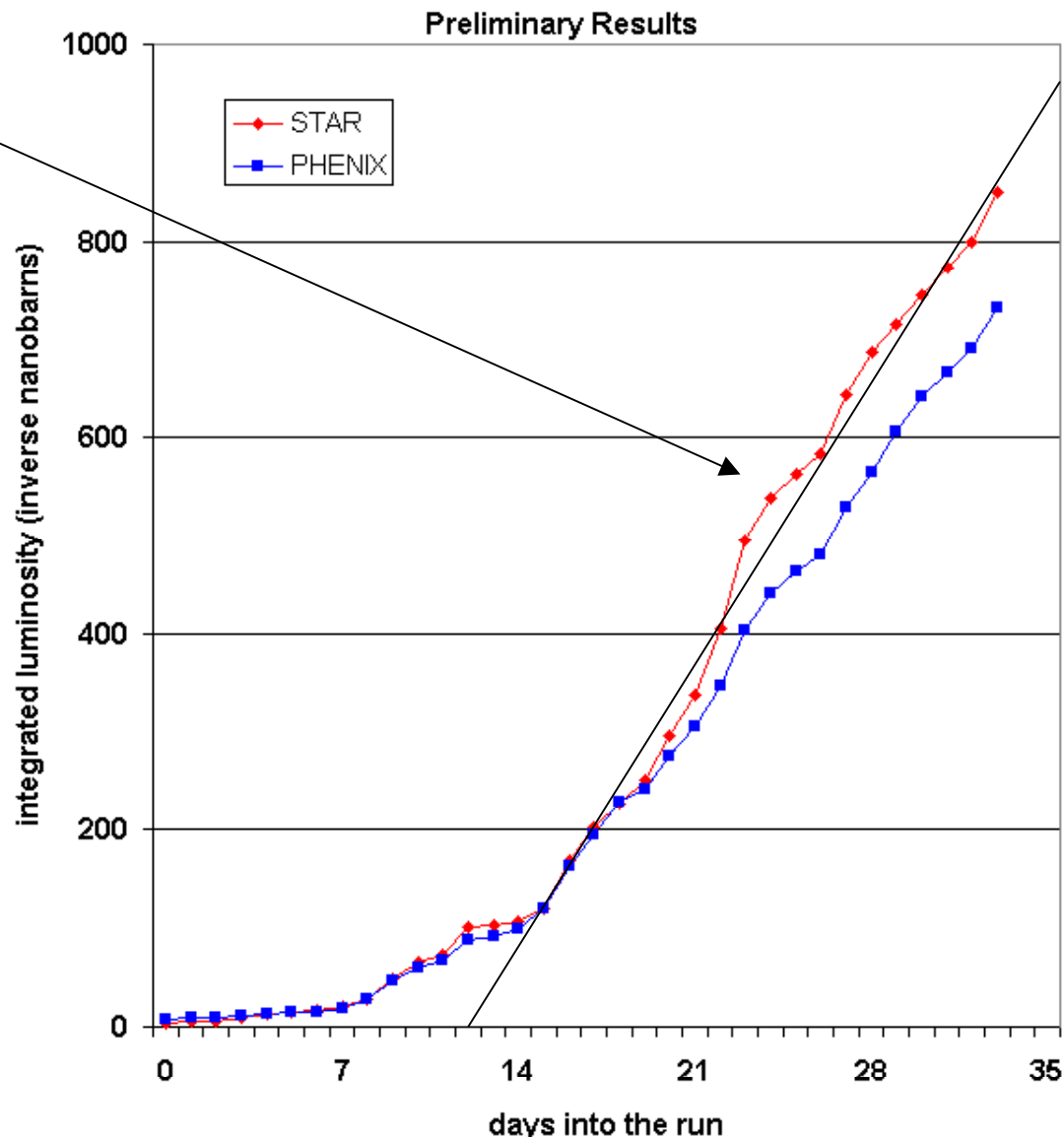
Integrated p - p luminosity

STAR during last 20 days:

$290 \text{ (nb)}^{-1}/\text{week}$

$L_{\text{ave}}(\text{week}) = 0.5 \times 10^{30} \text{ cm}^{-2} \text{ s}^{-1}$

$L_{\text{ave}}(\text{week})/L_{\text{ave}}(\text{store}) = 42 \%$



Results from first RHIC polarized proton run

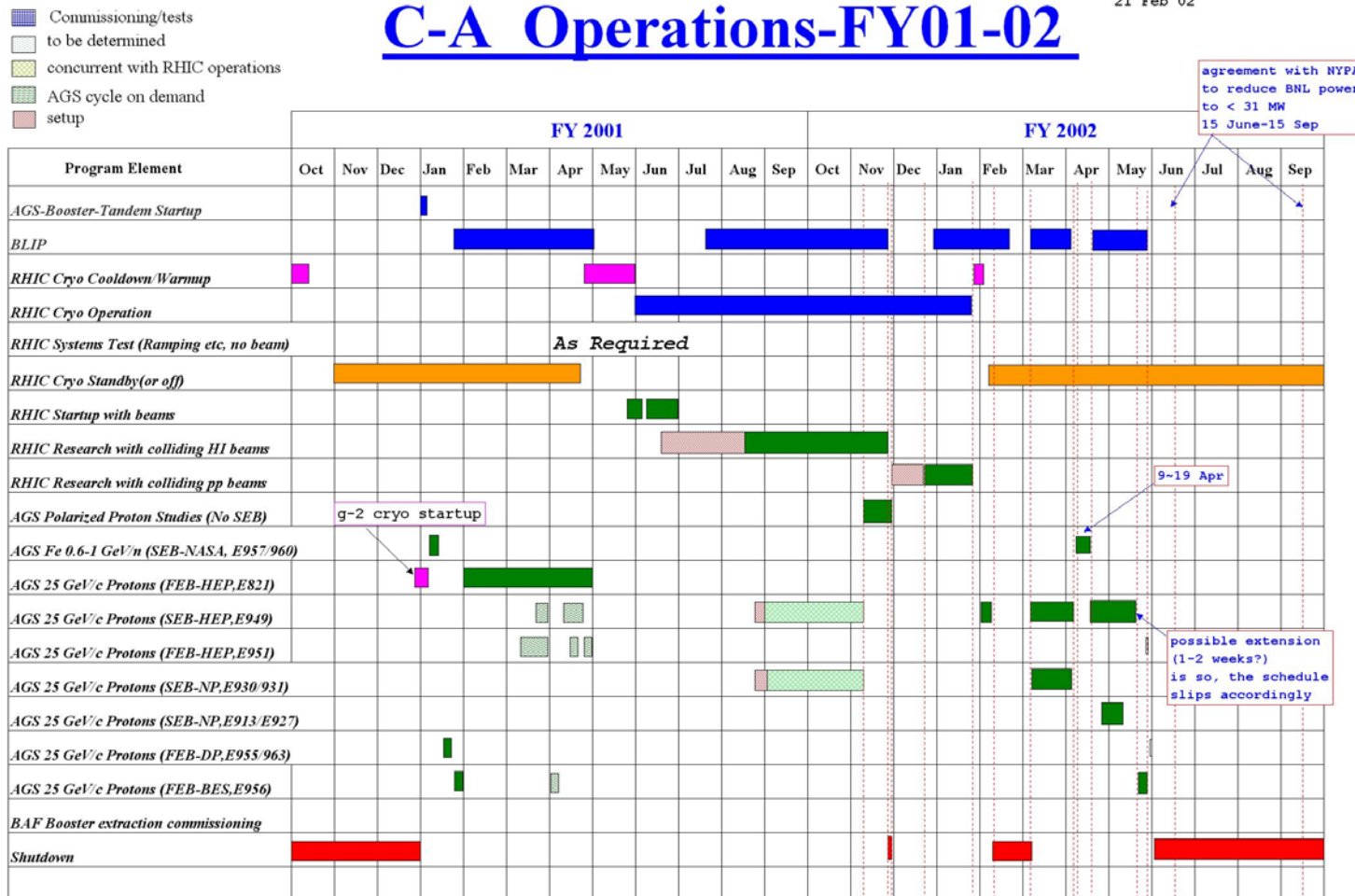
- 55 bunches per ring with 0.8×10^{11} p^\uparrow /bunch
- Charge/bunch and total charge higher than with gold beams
- Lattice with constant β^* of 3 m during ramp
- Peak luminosity at beginning of store: $1.5 \times 10^{30} \text{ cm}^{-2} \text{ s}^{-1}$
- Energy/beam: 100 GeV
- Beam polarization $\sim 25 \%$
RHIC polarimeters work reliably
- Little if any depolarization in RHIC during acceleration and store
Siberian Snakes work
- $\sim 60 \%$ polarization loss in AGS; aggravated by lower ramp-rate from Westinghouse motor-generator
- **Strong Siberian snake in AGS ($\sim 30 \%$ of full snake) could avoid all depolarization in the AGS**

C-A Operation FY2001-02

<http://server.c-ad.bnl.gov/esfd>

C-A Operations-FY01-02






21 Feb 02



C-A Operation FY2003-04

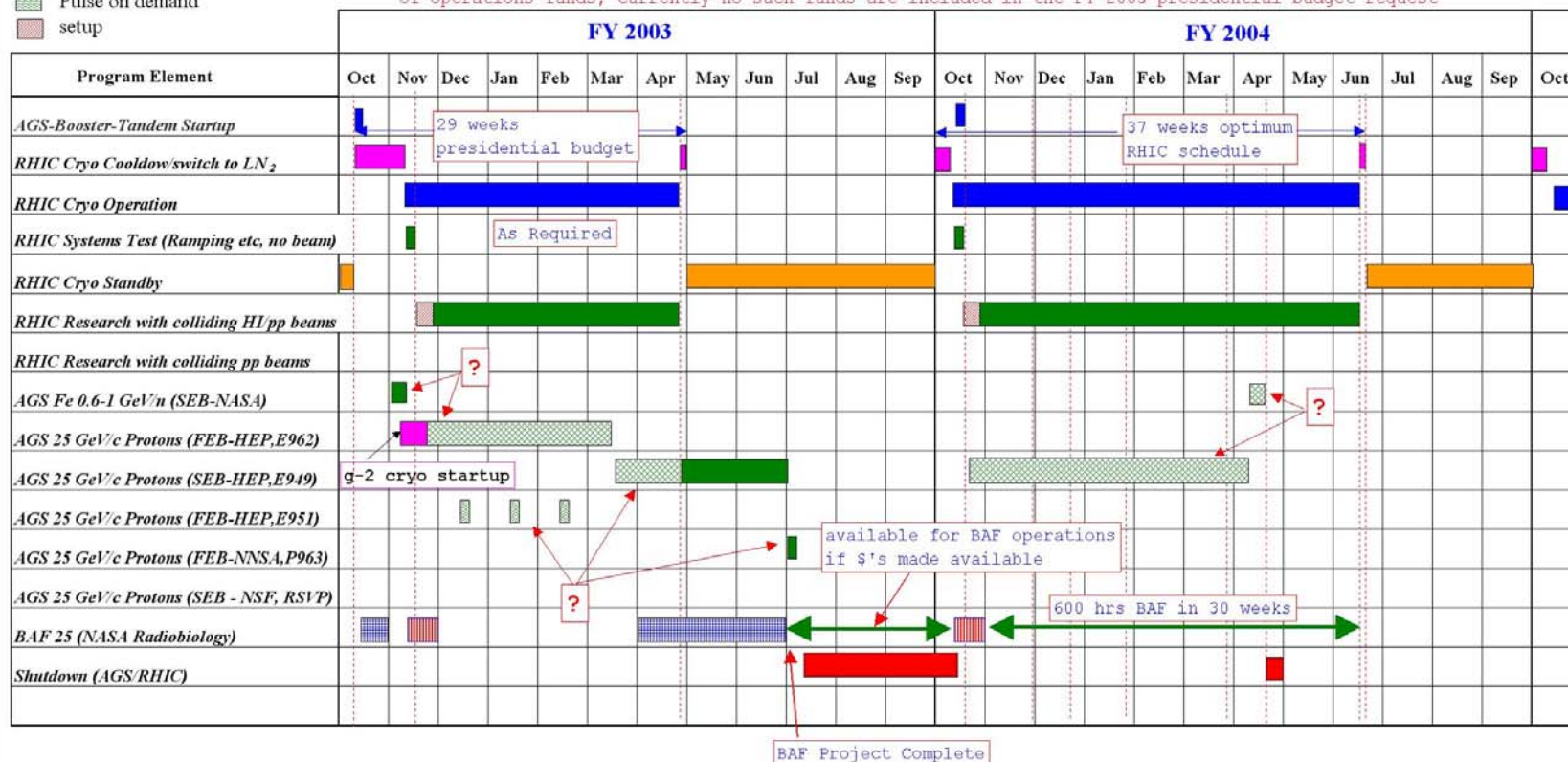
<http://server.c-ad.bnl.gov/esfd>

14 Feb 02

-  BAF/SEB/FEB operation blackout
-  Concurrent with RHIC operations
-  Commissioning
-  Pulse on demand
-  setup

C-A Operations-FY03-04

subject to funding etc. AGS fixed target experiments (FEB and SEB) are contingent upon restoration of operations funds, currently no such funds are included in the FY 2003 presidential budget request



RUN2003 Goals (~ 3-4 weeks into run)

- Prepare for four modes; all with:

Energy/beam: 100 GeV/nucleon, diamond length: $\sigma = 20$ cm, $L_{\text{ave}}(\text{week})/L_{\text{ave}}(\text{store}) = 40$ %

Mode	# bunches	Ions/bunch [$\times 10^9$]	β^* [m]	Emittance [$\pi\mu\text{m}$]	L_{peak} [$\text{cm}^{-2}\text{s}^{-1}$]	$L_{\text{ave}}(\text{store})$ [$\text{cm}^{-2}\text{s}^{-1}$]	$L_{\text{ave}}(\text{week})$ [week^{-1}]
Au-Au	56	1	1	15-40	14×10^{26}	3×10^{26}	$70 (\mu\text{b})^{-1}$
$(p\uparrow-p\uparrow)^*$	112	100	1	25	16×10^{30}	10×10^{30}	$2.8(\text{pb})^{-1}$
d-Au	56	100(d), 1(Au)	2	20	5×10^{28}	2×10^{28}	$5 (\text{nb})^{-1}$
Si-Si	56	7	1	20	5×10^{28}	2×10^{28}	$5 (\text{nb})^{-1}$

* Beam polarization ≥ 50 %; Acceleration test to 250 GeV

- New hardware installed and to be commissioned:
 - All eight spin rotators for PHENIX and STAR

RUN2003 Integrated Luminosity Estimate

Estimate for integrated luminosity for 29 week FY2003 run:

- 4 weeks cool down, 1 week warm-up, 2 weeks setup (for each mode),
3 weeks ramp up (for each mode): →
29 weeks of cryo ops.: 2 modes: 7 weeks at “final” luminosity / mode
 3 modes: 3 weeks at “final” luminosity / mode
 4 modes: 1 week at “final” luminosity / mode
- Minimum: performance at end of FY2001/02 run
- Maximum: luminosities from previous slide

Mode	L_{ave} (week) [week ⁻¹]	Int. Lumi. 2 modes	Int. Lumi. 3 modes	L_{ave} (week) [week ⁻¹]	Int. Lumi. 2 modes	Int. Lumi. 3 modes
Au-Au	$24(\mu\text{b})^{-1}$	$168(\mu\text{b})^{-1}$	$72(\mu\text{b})^{-1}$	$70(\mu\text{b})^{-1}$	$490(\mu\text{b})^{-1}$	$210(\mu\text{b})^{-1}$
(p↑-p↑)*	$0.3(\text{pb})^{-1}$	$2.1(\text{pb})^{-1}$	$0.9(\text{pb})^{-1}$	$2.8(\text{pb})^{-1}$	$19.6(\text{pb})^{-1}$	$8.4(\text{pb})^{-1}$
d-Au	?	?	?	$5(\text{nb})^{-1}$	$35(\text{nb})^{-1}$	$15(\text{nb})^{-1}$
Si-Si	?	?	?	$5(\text{nb})^{-1}$	$35(\text{nb})^{-1}$	$15(\text{nb})^{-1}$

HERA and LEP luminosity

